

PROJECTION OPTICAL SYSTEM AND PROJECTION
TYPE DISPLAY APPARATUS USING THE SAME

BACKGROUND OF THE INVENTION

5 Field of the Invention

This invention relates to a projection type image display apparatus.

Related Background Art

With the arrival of the multimedia age, image
10 display apparatuses are used in all scenes.
Particularly, a projection type image display apparatus is easy to widen its image plane and therefore, front projectors have spread for presentation use, etc. and rear projectors have
15 spread for home theater use, etc.

CRT's have heretofore been utilized as the light modulating elements of these projectors. In recent years, however, with the requirements for higher luminance and higher resolution, as light
20 modulating elements suitable for these requirements, the utilization of liquid crystal panels and DMD's (digital mirror devices, see, for example, Japanese Patent Application Laid-Open No. 10-78550) is becoming the mainstream. A
25 projection type image display apparatus utilizing the liquid crystal panel or the DMD illuminates the liquid crystal panel or the DMD as the light

2016-11-16 14:40:00

modulating element with light from a light source,
and forms transmitted light or reflected light
from the liquid crystal panel or the DMD into an
image on a screen through a projection optical
5 system.

Now, the projection type image display
apparatus has not yet reached the quality of image
of a direct view type CRT image display apparatus
in high image quality display (display of which a
10 feeling of quality is required). The high image
quality (feeling of quality) referred to herein
refers to a high dynamic range (high contrast and
high gradation display). The direct view type CRT
image display apparatus realizes a dynamic range
15 of at least 10000 : 1 when it displays the entire
image plane in black and white. On the other hand,
the dynamic range of the projection type image
display apparatus is determined chiefly by the
characteristic of the light modulating element,
20 and is about 300 to 400 : 1 in the case of the
liquid crystal panel, and about 600 to 800 : 1 in
the case of the DMD. This lowness of the dynamic
range is attributable to the fact that in black
display, in the case of a transmission type liquid
25 crystal panel, leak light, and in the case of a
reflection type liquid crystal panel or the DMD,
scattered light is projected and a dark state

floats.

So, in a projection type image display apparatus using a scattering type liquid crystal panel disclosed in Japanese Patent Application
5 Laid-Open No. 7-84553, a large aperture diameter and a small aperture diameter are prepared in the stop of a projection optical system, and they are changed over in conformity with the kind of an input image to thereby make display improved in
10 dynamic range possible.

However, the example shown in Japanese Patent Application Laid-Open No. 7-84553 suffers from the problem that the display improved in dynamic range is made possible, but luminance is lowered and the
15 feeling of sharpness lacks.

Also, there has been actualized the problem that by the aperture diameter being made small, the brightness distribution of a projected image is varied (usually the marginal portion becomes
20 relatively dark).

SUMMARY OF THE INVENTION

So, the present invention has as its object to provide a projection type image display
25 apparatus keeping the uniformity of brightness and the feeling of sharpness and yet achieving a high image quality called a high dynamic range.

In one aspect of the invention, a projection type display apparatus includes a projection optical system for projecting image light from a display device, and the projection optical system
5 has light amount adjusting means capable of substantially uniformly attenuating the image light in the cross-section thereof.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting
10 means has a variable stop comprising a plurality of tiltable light intercepting plates arranged in the cross-section.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting
15 means has a variable stop comprising a plurality of displaceable light intercepting plates arranged in the cross-section.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting
20 means has ND filter means variable in transmittance.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a stop variable in aperture diameter.

25 In further aspect of the foregoing projection type display apparatus, a write signal to the display device is modulated in synchronism with

the adjustment of the amount of light by the light amount adjusting means so that the dynamic range about luminance may change.

In further aspect of the foregoing projection
5 type display apparatus, the display device
includes a light modulating element and
illuminating means for illuminating the light
modulating element with light from a light source,
and the illuminating means has a first optical
10 system for forming a plurality of light source
images by the light from the light source, and a
second optical system for superimposing the beams
from the plurality of light source images on the
light modulating element, and the light amount
15 adjusting means is disposed at a position whereat
the plurality of light source images are projected.

In another aspect of the invention, a
projection type display apparatus includes:

a projection optical system for projecting
20 image light from a display device;

light amount adjusting means for adjusting
the amount of the image light; and

control means for attenuating the amount of
light of the whole of the image light by the light
25 amount adjusting means and modulating a write
signal to the display apparatus so that the
dynamic range about luminance may be expanded.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means substantially uniformly attenuates the image light in the cross-section thereof.

5 In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a variable stop comprising a plurality of tiltable light intercepting plates arranged in the cross-section.

10 In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a variable stop comprising a plurality of displaceable light intercepting plates arranged in the cross-section.

15 In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has ND filter means variable in transmittance.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a stop variable in aperture diameter.

In further aspect of the foregoing projection type display apparatus, the projection optical system has the light amount adjusting means.

25 In further aspect of the foregoing projection type display apparatus, the display device includes a light modulating element driven in

conformity with the write signal, and illuminating means for illuminating the light modulating element with light from a light source, and the illuminating means has a first optical system for
5 forming a plurality of light source images by the light from the light source, and a second optical system for superimposing beams from the plurality of light source images on the light modulating element, and the light amount adjusting means is
10 disposed at a position whereat the plurality of light source images are projected.

In further aspect of the foregoing projection type display apparatus, the illuminating means has the light amount adjusting means.

15 In further aspect of the foregoing projection type display apparatus, the projection optical system has the light amount adjusting means.

In another aspect of the invention, a projection type display apparatus includes:

20 a light modulating element for controlling the transmitted or reflected state of light to thereby display a gradation image;

an illuminating device for applying light to the light modulating element;

25 a projection optical system for projecting the transmitted light or reflected light of the light applied to the light modulating element;

write signal processing means for modulation-
processing a write signal to the light modulating
element;

projection light amount control means for
5 controlling the amount of light in the optical
path between the optical type integrator of the
illuminating apparatus to the projection optical
system; and

control signal generating means for
10 controlling the write signal processing means and
the projection light amount control means;

wherein the control signal generating means
generates a control signal on the basis of the
luminance level of an input image signal so as to
15 make the amount of projection light great and the
modulation of the write signal small when the
luminance level is high, and to make the amount of
projection light small and the modulation of the
write signal great when the luminance level is low.

20 In further aspect of the foregoing projection
type display apparatus, the projection light
amount control means adjusts the amount of light
in the optical path between the illuminating
device to the light modulating element and/or
25 between the light modulating element to the
projection optical system.

In further aspect of the foregoing projection

2007-04-10 14:44:44

type display apparatus, the projection light amount control means uniformly intercepts a light source image formed by the optical type integrator.

In further aspect of the foregoing projection
5 type display apparatus, the projection optical system is a so-called schlieren optics.

In further aspect of the foregoing projection type display apparatus, the projection light amount control means has movable stop means and
10 stop driving means.

In further aspect of the foregoing projection type display apparatus, the projection light amount control means is disposed at a position which is not in conjugate relationship with the
15 light modulating element.

In further aspect of the foregoing projection type display apparatus, the projection light amount control means controls the amount of stop in conformity with the luminance level of the
20 input image signal.

In further aspect of the foregoing projection type display apparatus, the movable stop means of the projection light amount control means is a stripe stop, and the driving means is a cam motor
25 or an ultrasonic motor.

By "stripe stop" is here meant a stop that has a plurality of light intercepting portions

arranged in one direction with a given interval.

In further aspect of the foregoing projection
type display apparatus, the control signal
generating means has luminance level calculation
5 means for calculating the luminance level of the
input image signal, and projection light amount
calculation means for calculating the amount of
projection light emerging from the projection
optical system in conformity with the calculated
10 luminance level, and generates the control signal
of the projection light amount control means on
the basis of the amount of projection light
calculated in the projection light amount
calculation means, and generates the control
15 signal of the write signal processing means on the
basis of the luminance level calculated in the
luminance level calculation means and the
calculated amount of projection light.

In further aspect of the foregoing projection
20 type display apparatus, the luminance level
calculation means calculates the maximum value of
the luminance signal of each pixel in each field
or each frame of an image signal as maximum
luminance.

25 In further aspect of the foregoing projection
type display apparatus, the luminance level
calculation means calculates the cumulative

histogram of the luminance signal of each pixel in
each field or each frame of an image signal, and
calculates a luminance level at which the
cumulative histogram becomes constant or greater
5 as maximum luminance.

In further aspect of the foregoing projection
type display apparatus, the write signal
processing means modulates the write signal so as
to amplify it at an amplification factor
10 substantially inversely proportional to the amount
of projection light.

In further aspect of the foregoing projection
type display apparatus, the light amount control
means is disposed at the pupil position of the
15 projection optical system.

In another aspect of the invention, a
projection type display apparatus includes:

a projection optical system for projecting an
image onto a screen; and
20 light amount control means for uniformly
intercepting a light source image projected onto
the pupil of the projection optical system.

In another aspect of the invention, a
projection optical system for projecting image
25 light, the projection optical system having light
amount adjusting means capable of substantially
uniformly attenuating the image light in the

cross-section thereof.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a variable stop comprising a plurality
5 of tiltable light intercepting plates arranged in the cross-section.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a variable stop comprising a plurality
10 of displaceable light intercepting plates arranged in the cross-section.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has ND filter means variable in
15 transmittance.

In further aspect of the foregoing projection type display apparatus, the light amount adjusting means has a stop variable in aperture diameter.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the system construction of a liquid crystal projector according to an embodiment of the present invention.

Figs. 2A and 2B show the structure of a
25 stripe stop according to the embodiment of the present invention.

Fig. 3 shows the layout relationship between

the stripe stop according to the embodiment of the present invention and a light source image.

Figs. 4A and 4B are histograms showing the luminance level distributions of an input image
5 signal.

Figs. 5A and 5B are cumulative histograms showing the luminance level distributions of the input image signal.

Figs. 6A and 6B illustrate the modulation of
10 a write signal into a light modulating element according to the embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

15 An embodiment of the present invention will hereinafter be described with reference to Fig. 1.

An image display apparatus according to the present invention, as indicated by reference numeral 1 in Fig. 1, includes a light modulating
20 element P for controlling the state of the transmission or reflection of light to thereby display a gradation image, an illuminating optical system BL1 for applying light to the light
25 system PL1 for projecting the transmitted light or reflected light of the light applied to the light modulating element P, and is designed to project

this projection light onto a screen, not shown, to thereby display an image.

The image display apparatus further includes write signal processing means 10 for modulation-
5 processing a write signal to the light modulating element, projection light amount control means 20 for controlling the amount of light transmitted through or reflected from the light modulating element, and control signal generating means 30
10 for controlling the write signal processing means 10 and the projection light amount control means 20.

The control signal generating means 30 may preferably generate a control signal so as to make
15 the amount of projection light great and the modulation of the write signal small (attenuate the amount of the whole image light by light amount adjusting means and modulate the write signal to the display apparatus so that the
20 dynamic range of luminance may widen) on the basis of the luminance level of an input image signal when the luminance level is high, and generate a control signal so as to make the amount of projection light small and the modulation of the
25 write signal great (increase the amount of the whole image light by the light amount adjusting means and modulate the write signal to the display

apparatus so as to reduce the dynamic range of luminance) when the luminance level is low.

The projection optical system PL1 in the present apparatus may preferably be comprised of a so-called schlieren optics (inverse schlieren). Also, the projection light amount control means 20 is comprised of movable stop means 20a and stop driving means 20b, and is disposed at the pupil position of the projection optical system PL1 which is a position not in conjugate relationship with the light modulating element P. Also, an integrator type illuminating optical system is used as the illuminating optical system BL1, and a matrix-shaped light source image by an optical type integrator is formed at or near the position of the movable stop means 20a. As the optical type integrator, there is a kaleidoscope (also called a "rod type integrator") besides a fly-eye lens used in the present embodiment.

The projection light amount control means 20 may preferably control the aperture amount by opening or closing the movable stop means 20a in conformity with the luminance level of the input image signal.

Now, the above-described control signal generating means 30 is comprised of luminance level calculation means 30a for calculating the

luminance level of the input image signal, and
projection light amount calculation means 30b for
calculating the amount of projection light
emerging from the projection optical system in
5 conformity with the calculated luminance level.
The control signal generating means 30 may
preferably generate a control signal for
controlling the projection light amount control
means 20 on the basis of the amount of projection
10 light calculated in the projection light amount
calculation means 30b, and generate a control
signal for controlling the write signal processing
means 10 on the basis of the luminance level
calculated in the luminance level calculation
15 means 30a and the calculated amount of projection
light.

The luminance level calculation means 30a may
preferably calculate the maximum value of the
luminance signal of each pixel in each field or
20 each frame of the input image signal as maximum
luminance. In this case, the maximum value can be
calculated by comparing the input image signal in
a field or a frame in succession.

Alternatively, it may preferably calculate
25 the cumulative histogram of the luminance signal
of each pixel, and calculate a luminance level at
which the cumulative histogram is constant or

greater as maximum luminance. Here, if an image
signal of which the luminance level in a field or
a frame has a distribution shown in Fig. 4A or Fig.
4B is inputted, when the cumulative histogram is
5 calculated from the higher luminance level, it
becomes such as shown in Fig. 5A or Fig. 5B. The
luminance level at which this cumulative histogram
reaches e.g. 5% of the total image plane is
calculated as maximum luminance. Accordingly, it
10 is 216 in the example of Fig. 5A, and is 117 in
the example of Fig. 5B. The control stages of the
movable stop means 20a can be rendered into 255
stages in accord with the gradation of the input
image, but practically may be rendered into the
15 order of 8 to 16 stages. When the movable stop
means is to be controlled at 8 stages, it is
controlled at 7 of the 8 stages in the example of
Fig. 5A, and at 4 of the 8 stages in the example
of Fig. 5B, that is, so as to be 87.5% and 50%,
20 respectively, of the maximum amount of light.

Also, the write signal processing means 10
may preferably modulate the write signal so as to
amplify it at an amplification factor
substantially inversely proportional to the
25 aforementioned amount of projection light.

Now, as the light modulating element, mention
can be made of an element using liquid crystal,

MEMS (micro electromechanical systems) type
element typified by the DMD of TI Co., or an
element having a micromirror disposed therein.
This light modulating element P may be of the
5 transmission type or the reflection type.

Also, the movable stop means 20a is a stripe
stop as shown in Figs. 2A and 2B. By "stripe
stop" is here meant a stop that has a plurality of
light intercepting portions arranged in one
10 direction with a given interval. The plurality of
light intercepting portions are preferably a
plurality of stop vanes explained in below, which
have substantially rectangular shapes as shown in
Figs. 2A and 2B, and a plurality of stop vanes are
15 arranged parallel with shorter sides of the
rectangular shape thereof. The stopping operation
is performed by the rotating operation on the
rotary shafts of a plurality of stop vanes, and
the stop driving means 20b is a cam motor or an
20 ultrasonic motor for rotating the rotary shafts.
Further, as shown in Fig. 3, in the movable stop
means 20a, a plurality of strip-shaped stop vanes
constituting the stripe stop are formed at such a
pitch as accords with the arrangement of the unit
25 images of the aforescribed light source image.

The action of the present embodiment will now
be described.

When a high luminance level (e.g. a maximum
luminance level 255 on the assumption that the
gradation of the input image signal is 8 bits) is
now present in the input image signal, the dynamic
5 range of the light modulating element P is all
used and therefore is not subjected to the
modulating process in the write signal processing
means 10, and in the projection light amount
control means 20, the movable stop means 20a is
10 controlled so that the aperture thereof may become
largest, and 100% of the light transmitted or
reflected in the light modulating element P is
used as projection light. At this time,
unnecessary transmitted light or scattered light
15 created by the light modulating element P emerges
from the projection optical system PL1 through the
aperture which has become largest, and black
display floats. However, the human eyes
relatively recognizes luminance with the maximum
20 luminance in the image plane as the reference and
therefore, when the luminance level of the display
image plane is high, the float of black is not so
conspicuous.

On the other hand, when the luminance level
25 of the input image signal is low (e.g. a maximum
luminance level 128 on the assumption that the
gradation of the input image signal is 8 bits),

the used dynamic range of the light modulating
element P is about 50% and the amount of light
required for projection is 50%. Accordingly, the
projection light amount control means 20 controls
5 the aperture of the movable stop means 20a so that
the amount of projection light may become 50%.
Further, in this state, the entire displayed image
becomes a dark display and therefore, the light
modulating element P is subjected to the
10 modulating process so as to amplify the signal so
that the dynamic range of the light modulating
element P may be used by 100% in the write signal
processing means 10. That is, the dynamic range
of the light modulating element P is used by 100%
15 and the display of the amount of projection light
50% is effected. The amount by which the amount
of projection light has been thus stopped down by
the projection light amount control means 20 is
compensated for by the write signal processing
20 means 10, whereby a display keeping the actual
display luminance level constant becomes possible.
At this time, the unnecessary transmitted light or
scattered light created by the light modulating
element P has its incidence onto the projection
25 optical system PL1 suppressed by the aperture
having become narrow. Accordingly, in this state,
a display in which black is firm can be effected.

The effect of the present embodiment will now be described.

According to the present embodiment, when the amount of projection light is stopped down by the projection light amount control means 20, the incidence of the unnecessary scattered light from the light modulating element P onto the projection optical system PL1 is suppressed and a firmer black display can be effected. That is, the amount of projection light is controlled in conformity with the maximum luminance level of the input image signal and also, the write signal of the light modulating element P is subjected to the modulating process, whereby it becomes possible to improve the floating of black display without changing the display luminance level, and a display in which the display dynamic range is enlarged relative to the luminance of 100% displayed in terms of a maximum amount of light can be effected.

Also, when the luminance level of the displayed image is low, the input image signal is subjected to the modulating process and the image signal is expanded, whereby the gradation of the displayed image can be improved.

Also, in the present embodiment, as previously described, a plurality of stop vanes

constituting the movable stop means 20a are formed
in accord with the arrangement of the unit images
of the light source image by the integrator, and
the stop vanes are rotated to thereby uniformly
5 intercept each unit image and therefore, even in
the case of the amount of projection light being
freely stopped down, a uniform brightness
distribution image is always obtained, and the
enlarged projection image of the dynamic range
10 under such a uniform brightness distribution
becomes possible.

The present invention will hereinafter be
described in greater detail with respect to an
embodiment thereof.

15 (Embodiment)

In the present embodiment, use is made of the
projection type image display apparatus as shown
in Fig. 1.

In the present embodiment, a reflection type
20 DMD panel P is used as the light modulating
element, the panel P is illuminated by the
illuminating optical system BL1, a movable stop
(movable stop means) 20a and the projection
optical system PL1 are disposed in the named order
25 on the side toward which the light is reflected by
the panel P, and a screen (not shown) for image
projection is disposed forwardly thereof.

Describing in greater detail, regarding the constituents of the illuminating optical system BL1, reference numeral 3 designates a reflector for a lamp, reference numeral 2 denotes a lamp
5 (light emitting tube), reference numeral 4 designates a rotary color filter, reference characters 5a and 5b denote telecentric lenses, reference characters 6a and 6b designate fly-eye integrators, and reference numeral 7 denotes a
10 condensing reflecting mirror. Also, the projection optical system PL1 is a so-called projection lens of a predetermined numerical aperture and a predetermined focal length (variable).

15 The light emitted from the lamp 2 is first reflected and condensed by the reflector 3 and passes through the rotary color filter 4 at a condensing point, whereby it is converted into a color light (RGB or RGBW) and thereafter comes to
20 the lenses 5a and 5b in its widened state. It is made telecentric by the condensing action of the lenses 5a and 5b and is subjected to the ante-processing of the integrating action by the fly-eye integrators 6a and 6b and passes therethrough
25 to the condensing and reflecting mirror 7, where it is reflected and condensed (by this condensing, the integrating action by the aforescribed fly-

eye integrators 6 is realized) and uniformly illuminates the DMD panel P. The DMD panel P reflects only the image light of the thus illuminating beam in a direction to pass through
5 the movable stop means 20a by the modulating action of each pixel mirror, and the image light is enlarged and projected onto a screen, not shown, through the projection optical system PL1. At this time, the matrix-shaped light source image by
10 the fly-eye integrators 6 is formed at or near the position of the movable stop means 20a. While the movable stop means 20a is disposed more adjacent to the projection optical system PL1 than to the DMD panel P, the movable stop means 20a can
15 achieve a similar effect even if it is disposed more adjacent to the lamp 2 than to the DMD panel P. In that case, it is preferable to provide the movable stop means near the fly-eye integrators 6 or at a position conjugate with the fly-eye
20 integrators 6.

Also, the movable stop means 20a, as shown in detail in Figs. 2A and 2B, is a stripe stop in which a plurality of stop vanes perform the stopping operation by the rotating operation
25 thereof on the rotary shafts thereof, and the stop driving means 20b comprises a cam motor or an ultrasonic motor for rotating the rotary shafts.

Further, as shown in Fig. 3, strip-shaped stop vanes constituting the stripe stop are disposed at such a pitch as accords with the arrangement of the unit images of the afore-described light

5 source image 60.

Also, in the present embodiment, a DMD panel is so-called RGB-sequentially driven, and this RGB sequential driving is synchronized with the rotation of the rotary color filter 4 so that a
10 predetermined color light may illuminate the DMD panel.

The write signal processing circuit 10 is connected to the DMD panel P, and the control signal generating circuit 30 is connected to the
15 write signal processing circuit 10 and the stop driving ultrasonic motor 20b. The control signal generating circuit 30 has already been described and therefore need not be described any further.

The action of the present embodiment will now
20 be described.

Now, on the basis of the luminance level of the input image signal, the write signal to the movable stop means 20a and the DMD panel P is controlled so as to make the amount of projection
25 light great and the modulation of the write signal small when the luminance level is high, and so as to make the amount of projection light small and

the modulation of the write signal great when the luminance level is low.

This operation will now be described with reference to Figs. 6A and 6B. In Figs. 6A and 6B, the luminance level on the axes of ordinates is such that luminance level relative to the gradation of the input image signal when 100% of the reflected light from the DMD was used with the stop fully opened is displayed at 8 bits. Here, however, for the simplification of description, it is to be understood that the luminance level linearly changes relative to the change in the gradation of the input image signal. When the maximum luminance level of the input image signal is calculated as 255, the stop is controlled so as to be fully opened in order to use 100% of the reflected light from the DMD, and the write signal is not subjected to modulation. Next, when the maximum luminance of the input image signal is calculated as 128, the utilization of the reflected light from the DMD may be 50%. Accordingly, the stop is adjusted so that the amount of projection light may become 50%. At this time, by the amount of projection light being adjusted to 50%, the luminance level of the displayed image uniformly becomes 50%. For example, when the gradation of the input image

signal was 127, the luminance level was 127 (point A in Figs. 6A and 6B), whereas the luminance level becomes about 64 (point A' in Figs. 6A and 6B).

So, in order to compensate for this, the input
5 image signal is modulated. Specifically, it will suffice to bring the point A' in Figs. 6A and 6B to a point A", and this can be accomplished by doubling the input image signal.

Now, by the amount of projection light being
10 stopped, the zero luminance level (=blackdisplay) can be lowered as indicated by ΔBK in Figs. 6A and 6B), as compared with a case where the amount of projection light is made great. That is, when the luminance level is low, the unnecessary scattered
15 light from the DMD panel P is suppressed and a firmer black display is provided. Also, by the modulation of the write signal to the DMD panel P being effected in conformity with the control of the amount of projection light, compensation is
20 done so as to keep the medium luminance level of the displayed image constant.

Also, regarding the quality, and particularly the uneven brightness, of the projection image, in the case of the present embodiment, as previously
25 described, the stop vanes constituting the movable stripe stop 20a are disposed at such a pitch as accords with the arrangement of the unit images of

the light source image 60 and therefore, when the stop vanes are rotated to thereby stop down the amount of projection light, the unit images are equally intercepted and therefore, there is no
5 change in the number of the unit images by the stop amount, and a projection image of uniform brightness distribution is always obtained irrespective of the magnitude of the stop amount.

The effect of the present embodiment will now
10 be described.

According to the present embodiment, when the maximum luminance level of the input image signal is low, a firmer black display can be effected without the medium luminance level of the
15 displayed image being changed. Accordingly, a display in which the dynamic range is expanded becomes possible by the contrast with the white display when the maximum luminance level of the input image signal is high.

20 Also, the write signal to the DMD panel P is modulated so as to become great when the amount of projection light is controlled to a small amount, whereby it becomes possible to expand the gradational property of a low luminance level.

25 Further, it becomes possible to effect such expansion of the dynamic range and the gradational property always under a quality of image having a

stable and uniform brightness distribution.

Now, while the present embodiment uses a vertical type movable stripe stop, this is not restrictive, but use can be made of any construction which equally stops down the unit images of the light source image (attenuates the amount of light), and for example, a horizontal type stripe stop, or an oblique stripe stop or a matrix-shaped one.

Also, in the above-described embodiment, the movable stripe stop is tiltable, but the numerical aperture thereof changes depending on the angle of the screen when the stop is tilted. Also, in the present invention, instead of the above-described movable stripe stop, use may be made of a variable stop in which a plurality of light intercepting plates variable in numerical aperture by being displaced by a control signal are arranged in the cross-section of the image light, a variable stop variable in aperture diameter by a control signal, or an ND filter variable in transmittance by a control signal.

Also, while in the present embodiment, the DMD panel is used as the display device, this is not restrictive, but a liquid crystal panel of the transmission type or the reflection type can entirely likewise be handled.

Further, while in the above-described embodiment, the projection light amount control means 20 adjusts the amount of light in the optical path from the panel P to the projection optical system PL1, this is not restrictive, but the projection light amount control means 20 may adjust the amount of light in the optical path between the fly-eye integrators 6 of the illuminating optical system BL1 to the panel P, or the projection light amount control means 20 may adjust the amount of light in the optical path in the illuminating optical system BL1 and between the panel P to a screen, not shown.

As described above, according to the present invention, when the maximum luminance calculated from the image display signal is small, control is effected so as to lower the amount of projection light and also raise the level of the write signal to the light modulating element, whereby a firm black display can be effected while the display luminance level is kept constant. Accordingly, a display in which the display dynamic range is expanded by the contrast between the white display when the amount of projection light is made maximum and the black display when the amount of projection light is lowered can be accomplished in a state in which a uniform brightness distribution

is maintained.

Also, the gradation of the write signal of the light modulating element can be increased even at the same display luminance level and therefore, 5 an improvement in the gradational property in a low luminance level display can be accomplished also in a state in which a uniform brightness distribution is maintained.

2001-10-10 14:00:00